Listing of Claims

1. (Currently amended) A single mode optical waveguide fiber having a ~~radial~~ radially varying and ~~azimuthal~~ azimuthally asymmetric core comprising:

a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer, wherein the core region has a cylindrical shape and a point in the core region has cylindrical coordinates, radius r, azimuth angle φ, and centerline height z, and the radius of the core region is $r = r_o$, and the pre-selected portion of the radius is in the range $0 < \Delta r \leq r_o$;

the waveguide having a centerline parallel to the long dimension of the waveguide, and the waveguide having ~~at least one core sector~~ a plurality of core sectors, each core sector being bounded by a first and a second plane, and a segment of the core region periphery intersected by the first and the second plane, wherein the first and second planes each contain the centerline and form at the centerline an included angle $\varphi \leq 180\ ^{\circ}$,

in which, the core refractive index changes along at least a portion, Δr, of a pre-selected radius extending perpendicular to and outward from the centerline, and,

the core refractive index at least at a point at a pre-selected radius inside each of the ~~at least one core sector~~ sectors has a value different from the core refractive index value at least at a point at the pre-selected radius outside the ~~at least one~~ respective core sector, wherein the core has a first pair of opposing sectors each having a step index radial change in refractive index and a second pair of opposing sectors each having an α-profile radial change in refractive index.

2. (Canceled)

3.(Original) The single mode waveguide of claim 2, in which, the pre-selected portion of the radius is the segment $\Delta r = r_2 - r_1$, where, $0 \leq r_1 < r_2$ and $r_2 < r_o$.

4. (Original) The single mode waveguide of either claim 2 or claim 3 in which the pre-selected portion of the radius lies along any radius in at least one sector having included angle $0 < \varphi \leq 180\ ^{\circ}$.

5. (Original) The single mode waveguide of claim 2, in which, the pre-selected portion of the radius Δr is in the range $0 < \Delta r \leq r_o$, the azimuth angle of the radius is in the range $0 \leq \varphi \leq 360^\circ$, and the radius is drawn from any point z along the centerline.

6. (Original) The single mode waveguide of claim 2, in which, the pre-selected portion of the radius is the segment $\Delta r = r_2 - r_1$, where, $0 \leq r_1 < r_2$ and $r_2 \leq r_o$, the azimuth angle of the radius containing the segment is in the range $0 \leq \varphi \leq 360^\circ$, and the radius containing the segment is drawn from any point z along the centerline.

7. (Currently amended) The single mode waveguide of claim ~~2~~ 1, in which, the core has 4 sectors of equal volume numbered consecutively from 1 to 4 in a counter-clockwise azimuth direction, and the boundary planes of each sector have an included angle of 90 °, and sectors 1 and 3 have [[a]] the step index radial change in refractive index ~~defined by a function f(r)~~, and sectors 2 and 4 have [[a]] the α-profile radial change in refractive index ~~defined by a function g(r)~~.

8. (Canceled)

9. (Canceled)

10. (Original) The single mode waveguide of claim 2, in which the core has three sectors, and each sector comprises a volume of a first glass of constant refractive index embedded in a volume of a second glass of constant refractive index, in which the refractive index of the first glass is greater than the refractive index of the second glass.

11. (Original) The single mode waveguide of claim 10 in which each of the first glass volumes is an elongated body having its long axis aligned parallel to the centerline, wherein the perpendicular cross section of the elongated body is selected from the group consisting of a circle, an ellipse, and a parallelogram.

12. (Original) The single mode waveguide of claim 2, in which the core has three sectors, and each sector contains an elongated glass volume having a central portion, a first annular portion surrounding and in contact with the central portion, and at least one additional annular portion in contact with the annular portion which the at least one additional annular portion

surrounds, wherein the long axis of each of the elongated structures is parallel to the centerline.

13. (Original) The single mode waveguide of claim 12 in which the central portion is a cylinder having radius r_c and relative index Δ_c, and the annular regions are tubes having respective outer radii r_i and relative index Δ_i, where i = 1...n, and n is the number of annular portions, in which Δ_i for i = an even number is greater than Δ_i for i equal to an odd number.

14.(Original) The single mode waveguide of claim 2 in which the core has four sectors each sector comprising a first glass volume having relative index Δ_1, and embedded in the first glass volume of each sector is an elongated volume of a second glass having relative index Δ_2, wherein the respective elongated volumes are arranged symmetrically about the centerline.

15-21. (Withdrawn)

22.(Currently amended) A multimode optical waveguide fiber having a ~~radial~~ radially varying and ~~azimuthal~~ azimuthally asymmetric core comprising:

a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer;

the waveguide having a centerline parallel to the long dimension of the waveguide, and the waveguide having four core sectors each bounded by a first and a second plane, and a segment of the core region periphery intersected by the first and the second plane, wherein the first and second planes each contain the centerline and form at the centerline an included angle $\varphi \leq 180^{\circ}$, wherein,

the core region is of cylindrical shape and a point in the core region has cylindrical coordinates, radius r, azimuth angle φ, and centerline height z, and the radius of the core region is $r = r_o$, and the refractive index changes along a radius portion Δr in the range $0 < \Delta r \leq r_o$, wherein,

the four core sectors have equal volume numbered consecutively from 1 to 4 in a counter-clockwise azimuth direction, and the boundary planes of each sector having an included angle of 90°, and sectors 1 and 3 have a first radial change in refractive index

~~defined by a function f(r)~~, and sectors 2 and 4 have a second radial change in refractive index, wherein the first and second radial changes differ from each other ~~defined by a function g(r)~~.

23.(Currently amended) The waveguide of claim 22, in which, ~~g(r)~~ the first radial change is a step index profile and ~~f(r)~~ the second radial change is an α- profile.

24.(Currently amended) The waveguide of claim 22, in which, the four core sectors are of equal volume, the ~~bounding~~ boundary planes of each sector having an included angle of 90 °, the refractive index profile of each sector having a central portion of radius r_c and relative index Δ_c, extending between the planes bounding the sector,

a first annular region in contact with the central portion, having outer radius r_1, relative index Δ_1, and extending between the planes bounding the sector,

a second annular region in contact with the first annular region, having outer radius r_2, relative index Δ_2, and extending between the planes bounding the sector,

a third annular region in contact with the second annular region, having outer radius r_3, relative index Δ_3, and extending between the planes bounding the sector,

a first volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the first plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions,

a second volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the second plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions, wherein,

each of the remaining three sectors contain embedded volumes having surfaces bounded in a way corresponding to the volumes embedded in the first sector, wherein, the relative indexes and the radii follow the inequalities,

$0 \leq r_c < r_1 < r_2 < r_3 \leq r_o$ and $\Delta_c \geq \Delta_2 > \Delta_1 \geq \Delta_3$.

25. (Original) The waveguide of claim 22 in which the four core sectors each comprise a first glass volume having relative index Δ_1, and embedded in the first glass volume of each sector

is an elongated volume of a second glass having relative index Δ_2, wherein the respective elongated volumes are arranged symmetrically about the centerline.

26. (Currently amended) A multimode optical waveguide fiber having a ~~radial~~ radially varying and ~~azimuthal~~ azimuthally asymmetric core comprising:

a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer;

the waveguide having a centerline parallel to the long dimension of the waveguide, and the waveguide having four core sectors each bounded by a first and a second plane, and a segment of the core region periphery intersected by the first and the second plane, wherein the first and second planes each contain the centerline and form at the centerline an included angle $\varphi \leq 180\ ^{\circ}$, wherein,

the core region is of cylindrical shape and a point in the core region has cylindrical coordinates, radius r, azimuth angle φ, and centerline height z, and the radius of the core region is $r = r_o$, and the refractive index changes along a radius portion Δr in the range $0 < \Delta r \leq r_o$, wherein,

the core has three ~~sectors~~ parts, wherein the three parts each contain an elongated glass volume having a central portion, a first annular portion surrounding and in contact with the central portion, and at least one additional annular portion in contact with the annular portion which the at least one additional annular portion surrounds, wherein each of the elongated volumes has a long axis parallel to the centerline, and each ~~sector~~ part comprises a volume of a first glass of constant refractive index embedded in a volume of a second glass of constant refractive index, in which the refractive index of the first glass is greater than the refractive index of the second glass.

27.(Original) The waveguide of claim 26 in which each of the first glass volumes is an elongated body having its long axis aligned parallel to the centerline, wherein the perpendicular cross section of the elongated body is selected from the group consisting of a circle, an ellipse, and a parallelogram.

28. Canceled.

29.(Currently amended) The waveguide of claim ~~28~~ 26 in which the central portion is a cylinder having radius r_c and relative index Δ_c, and the annular regions are tubes having respective outer radii r_i and relative index Δ_i, where i = 1...n, and n is the number of annular portions, in which Δ_i for i = an even number is greater than Δ_i for i equal to an odd number.

30.(New) A single mode optical waveguide fiber having a radially varying and azimuthally asymmetric core comprising:

a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer, wherein the core region has a cylindrical shape and a point in the core region has cylindrical coordinates, radius r, azimuth angle φ, and centerline height z, and the radius of the core region is $r = r_o$, and the pre-selected portion of the radius is in the range $0 < \Delta r < r_o$;

the waveguide having a centerline parallel to the long dimension of the waveguide, and the waveguide having a plurality of core sectors, each sector being bounded by a first and a second plane, and a segment of the core region periphery intersected by the first and the second plane, wherein the first and second planes each contain the centerline and form at the centerline an included angle $\varphi < 180^\circ$,

in which, the core refractive index changes along at least a portion, Δr, of a pre-selected radius extending perpendicular to and outward from the centerline, and,

the core refractive index at least at a point at a pre-selected radius inside the at least one core sector has a value different from the core refractive index value at least at a point at the pre-selected radius outside the at least one core sector

the refractive index profile of each sector having:

a central portion of radius r_c and relative index Δ_c, extending between the planes bounding the sector,

a first annular region in contact with the central portion, having outer radius r_1, relative index Δ_1, and extending between the planes bounding the sector,

a second annular region in contact with the first annular region, having outer radius r_2, relative index Δ_2, and extending between the planes bounding the sector,

a third annular region in contact with the second annular region, having outer radius r_3, relative index Δ_3, and extending between the planes bounding the sector,

a first volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the first plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions,

a second volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the second plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions.

31.(New) The optical waveguide fiber of claim 30 wherein the core has four sectors of equal volume, the bounding planes of each sector having an included angle of 90 °.

32.(New) The optical waveguide fiber of claim 30 wherein $0 \leq r_c < r_1 < r_2 < r_3 \leq r_o$ and $\Delta_c \geq \Delta_2 > \Delta_1 \geq \Delta_3$.

33.(New) An optical waveguide fiber comprising:

a cylindrical core region in contact with a surrounding clad layer, the core region being disposed about a longitudinal axis, and the core region having a central glass part and a plurality of elongated voids disposed within the core region, whereby the core region is azimuthally asymmetric.

34.(New) The optical waveguide fiber of claim 33 wherein elongated voids are symmetrically disposed about the centerline.

35.(New) The optical waveguide fiber of claim 33 wherein four elongated voids are equally spaced about the centerline.